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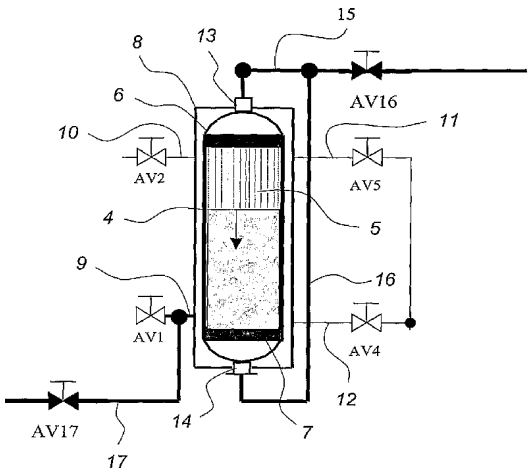
(54) Title: REDUCTION OF BACKWASH LIQUID WASTE



(57) Abstract: A method of filtering solids from a liquid suspension comprising providing a pressure differential across the walls of permeable, hollow membranes (5) immersed in the liquid suspension contained in a vessel (8), the liquid suspension being applied to the outer surface of the porous hollow membrane (5) to induce and sustain filtration through the membrane walls. Some of the liquid suspension passes through the walls of the membranes (5) to be drawn off as permeate from the hollow membrane lumens, and at least some of the solids are retained on or in the hollow membranes or otherwise as suspended solids within the liquid surrounding the membranes (5). The method includes the steps of suspending the flow of the liquid suspension to the vessel (8); reducing the volume of liquid suspension within the vessel (8); suspending the filtration process; cleaning the membranes (5) by dislodging at least some of th solids retained on or in the membranes (5); and removing the liquid containing dislodged solids from the vessel (8).

WO 2006/026814 A1

TITLE: REDUCTION OF BACKWASH LIQUID WASTE

TECHNICAL FIELD

The present invention relates to membrane filtration systems and, more particularly, to the reduction of liquid waste produced during backwashing of such systems.

BACKGROUND OF THE INVENTION

In a membrane filtration operation, periodically cleaning the membrane by liquid or gas backwash is essential to keep a longer membrane operation time without the need for a chemical cleaning stage. However, during each backwash, a certain amount of liquid waste is produced, which reduces the feed liquid recovery and increases the requirements on post treatment of backwash waste. For a customer plant, especially where customer has to purchase the feed, the feed recovery is an important plant performance factor.

DISCLOSURE OF THE INVENTION

According to one aspect of the present invention there is provided a method of filtering solids from a liquid suspension comprising:

(i) providing a pressure differential across the walls of permeable, hollow membranes immersed in the liquid suspension contained in a vessel, said liquid suspension being applied to the outer surface of the porous hollow membranes to induce and sustain filtration through the membrane walls wherein:

(a) some of the liquid suspension passes through the walls of the membranes to be drawn off as permeate from the hollow membrane lumens, and

(b) at least some of the solids are retained on or in the hollow membranes or otherwise as suspended solids within the liquid surrounding the membranes,

(ii) suspending the flow of the liquid suspension to said vessel;

(iii) reducing the volume of liquid suspension within said vessel;

(iv) suspending the filtration process;

(v) cleaning the membranes by dislodging at least some of the solids retained on or in the membranes; and

(vi) removing the liquid containing dislodged solids from said vessel.

Preferably, the cleaning step includes backwashing the membranes. For further preference, the cleaning step includes scouring the membrane surfaces with gas bubbles. For preference, the volume of liquid suspension within the vessel is reduced by continuing withdrawal of the permeate from the membranes while the flow of liquid suspension to the vessel is suspended. Preferably, the continuing withdrawal of permeate step includes applying gas pressure to the liquid suspension to assist the provision of said pressure differential across the membrane walls. The gas pressure may be applied by feeding aerating or scouring gas bubbles into the liquid suspension or by applying a separate source of gas pressure to the liquid suspension. In another aspect, the volume of liquid suspension in the vessel may be reduced by reversing the liquid suspension flow into the vessel. Preferably, the volume of liquid within the vessel is reduced to a predetermined level. For preference, the predetermined level is sufficient such that the membranes remain immersed in the liquid suspension during scouring and liquid backwash.

According to another aspect of the present invention there is provided a filtration system for removing solids from a liquid feed suspension comprising:

(i) a vessel for containing said liquid feed suspension;

(ii) means for providing a flow of liquid feed suspension to the vessel;

(iii) a plurality of permeable, hollow membranes within the vessel;

(iv) means for providing a pressure differential across walls of said membranes such that some of the liquid suspension passes through the walls of the membranes to be drawn off as permeate while at least some of the solids are retained on or in the hollow membranes or otherwise as suspended solids within the liquid surrounding the membranes,

(v) means for withdrawing permeate from the membranes;

(vi) means for reducing the volume of liquid suspension in the vessel;

(vii) means for suspending the withdrawal of permeate from the membranes;

(viii) means for cleaning the membranes by dislodging at least some of the retained solids from the membranes;

(ix) means for removing the liquid containing the solids from the vessel.

The methods of improving the feed recovery by pre-filtering down feed side feed water are described in relation to a pressurized membrane filtration system.

These methods use the aeration gas or the process gas to push the feed liquid through the membranes to produce the filtrate product and to reduce the liquid volume within the feed side of the vessel before the backwash process begins. Alternatively in some systems, the feed pump can be automatically

redirected to perform a suction to pull the feed side liquid level down. By using one of these methods, a portion of feed side liquid can be recovered and the feed recovery can be achieved to more than 99%.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows a schematic side elevation view of a membrane filtration module according to one embodiment of the present invention;

Figure 2 shows a schematic side elevation view of a membrane filtration module according to a second embodiment of the present invention;

Figure 3 shows a schematic side elevation view of a membrane filtration module according to a third embodiment of the present invention;

Figure 4 shows a schematic side elevation view of a membrane filtration module according to modification of the embodiment shown in Figure 3;

Figure 5 shows a graph of feed recovery vs feed flow with and without filtrate level being lowered; and

Figure 6 shows a bar graph of feed recovery for various systems.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to the drawings, a typical pressurized fibre membrane filtration module 4 is shown having a plurality of fibre membranes 5 extending between upper and lower headers 6 and 7 and mounted in a vessel 8. The supply of feed to the vessel 8 via lines 9 and 10 is controlled by respective valves AV1 and AV2. Filtrate may be withdrawn from both ends of the fibres 5 through ports 13 and 14 and lines 15 and 16 controlled by filtrate valve AV16.

In the preferred embodiments, the filtering-down process can be achieved using three different methods.

1) At the end of filtration period, aeration gas is introduced to the feed side to force the filtration to continue. Since the feed liquid flow into the module 4 is suspended, the continued filtration reduces the remaining liquid on the feed side of the membranes 5. The volume to be filtered depends on various factors. The more volume filtered, the less waste to be produced during the backwash. However, if the liquid volume left in the feed vessel 8 is too little, the gas scouring may not be effective because the module 4 is not fully immersed in the feed liquid and consequently the backwash efficacy will be affected. The liquid level remaining in the feed vessel 8 is preferably sufficient to just allow the module 4 to be fully immersed in the feed liquid during the gas scouring step.

2) The filtering down can also be realized by the introduction of process gas into the feed vessel 8 on the feed side to cause flow of feed liquid through the membranes 5 to the filtrate side. In this case, the feed side pressure can be higher resulting in a quicker process step.

3) Another option is to, at the end of the filtration period, reverse the feed pump 17 to draw some of the feed in the feed vessel 8 back to the feed source and therefore to reduce the discharge volume after backwash.

Each option will now be further described with reference to examples shown below.

Filtering down with aeration gas

Referring to Figure 1, before filtering down and backwash, the feed or shell side of the membranes is isolated via feed line/drain line valves AV1, 2, 4, 5. The filtrate valve AV16 remains open. Aeration gas is then injected through

valve AV17 and line 17 into a lower part of the module 4 and the feed side is pressurised by aeration gas pressure. The aeration gas source (not shown) can be compressed gas or blower air. The pressurization of feed side by aeration gas pushes feed liquid in the feed side through the membrane walls and produces filtrate which is withdrawn in the normal manner via lines 15 and 16. As the aeration gas is normally low pressure air and no pressure release is required, gas is continually injected into feed side until desired volume of filtrate is produced.

Once the filtering down step is completed, the aeration gas continues and the system enters a normal backwash sequence.

One advantage of using aeration gas as a source of gas pressure for filtering down is that it helps to clear liquid which fills the aeration manifold during filtration stage and reduces possible maldistribution when aeration starts. The gas injected during filtering down step also travels along membrane surface and provides the usual scouring effect.

When a flowmeter (not shown) is located in the filtrate side, it can be used to totalize the filtering down volume and feed back to a control system. The flowmeter feedback is used to control the filtering down volume to a preset value. In the case where no flowmeter is located in the filtrate side, a totalizing program can be implemented in a control PLC program utilizing membrane permeability and transmembrane pressure (TMP) to calculate the filtering down volume and control it to the preset value.

Filtering down with process air.

One disadvantage of filtering down with aeration gas is the limit of pressure it can deliver to the feed side. When filtrate side backpressure is high due to

operational reasons, the aeration gas may not be able to deliver high enough transmembrane pressure (TMP) to finish filtering down step in reasonable time frame. In such cases, as shown in Figure 2, process gas can be regulated down to 50 to 250 kPa and fed to the feed side via valve AV13 and line 19 to achieve the filtering down step. When process gas is used, the TMP can be controlled by adjusting the position of valve AV16. During filtering down, the filtration flow is controlled to be not more than normal filtration flow. When the process gas pressure is high, then the filtering down process is divided into two steps to reduce feed side pressure at the end of filtering down. In step one of the filtering down process, valves AV13 and AV16 are opened, process gas enters the top section of membrane vessel 8 and pushes liquid through the membrane walls. In step two of the filtering down process, valve AV13 is closed while valve AV16 continues to be open. Remaining compressed gas in the feed side continues to push liquid through membrane walls. While the feed side liquid volume reduces, the feed side gas pressure also drops and the desired filtering down volume and/or feed side pressure are achieved.

Another advantage of separating the filtering down process into two steps is the reduction in compressed gas consumption. In a similar fashion to the filtering down method using aeration gas, either a filtrate side flow meter or PLC programmed totalizer can be used to control the filtering down process.

Filtering down with pump reverse to filtrate suction pump

As shown in Figure 3, filtering down can also be achieved by filtrate suction applied to the membrane lumens by a pump 17. A separate suction pump may be installed as dedicated filtering down pump. If the system has a liquid backwash pump, then this pump can be reversed in direction to suck the filtrate

from the fibre lumens, reducing the liquid level in the feed vessel 8. Alternatively, the feed pump 17 can be used as a filtrate suction pump by adding valves AV20 and AV21 to achieve the filtering down step. The process can be divided into two steps. In the first step, valve AV16 is closed and valves AV20 and AV1 are opened providing a re-circulation flow from filtrate side to feed side. The main purpose of this step is to clean the feed pump 17 and relative piping before sending filtrate to product. The step typically only last a few seconds. To improve the cleaning efficiency, valve AV21 is located as close as possible to the discharge line of the pump and before valve AV1. Once the feed pump and pipes are cleaned, step two of the filtering down process starts and valve AV1 is closed while valve AV21 is opened. Again, the filtering down volume may be controlled by a filtrate flow meter or PLC programmed filtrate totalizer (not shown).

- By using this method the feed pump and pipe are cleaned by opening valves AV20 and AV1 to provide filtrate to feed side recirculation for a short period of time.

- In this method using a pump enables the filtering down of liquid on the feed side of the vessel to be effectively regulated. Valve AV21 is position-controlled to achieve desired filtering down flow rate. When feed liquid quality is poor, feed pump and line may not be able to cleaned well for filtrate delivery, the process can be modified to send filtrate to feed manifold before valve AV0 or a feed break tank. In the case of sending filtrate to feed manifold or break tank, the process is shown in Figure 4.

Another possible method to save the feed side liquid before backwash is to simply reverse feed pump flow direction and open AV1, AV5 and AV0 sending feed side liquid back to the feed line.

The advantage of using a pump to carry out filtering down step is that the time to filter down to a desired backwash level can be significantly shortened.

With a filtering down process, backwash waste can be significantly reduced and feed recovery improved. Backwash waste volume per backwash with filtering down can be reduced by as much as 60% of the original backwash liquid waste volume without filtering down. Figure 5 shows feed recovery at different filtration flow rate compared to recovery without filtering down in a current system.

Typical recovery with a filtering down process of this system is compared to another pressurized membrane system and one submerged system in Figure 6.

The description in this specification is focused on the outside-in filtration in hollow fiber membrane modules. The principle and the methods described above can also be applied to the mode of inside-out filtration for hollow membrane modules and other types of membrane modules such as flat sheet and spiral wound modules.

It will be appreciated that further embodiments and exemplifications of the invention are possible without departing from the spirit or scope of the invention described.

CLAIMS:

1. A method of filtering solids from a liquid suspension comprising:

(i) providing a pressure differential across the walls of permeable, hollow membranes immersed in the liquid suspension contained in a vessel, said liquid suspension being applied to the outer surface of the porous hollow membranes to induce and sustain filtration through the membrane walls wherein:

(a) some of the liquid suspension passes through the walls of the membranes to be drawn off as permeate from the hollow membrane lumens, and

(c) at least some of the solids are retained on or in the hollow membranes or otherwise as suspended solids within the liquid surrounding the membranes,

(ii) suspending the flow of the liquid suspension to said vessel;

(iii) reducing the volume of liquid suspension within said vessel;

(iv) suspending the filtration process;

(v) cleaning the membranes by dislodging at least some of the solids retained on or in the membranes; and

(vi) removing the liquid containing dislodged solids from said vessel.

2. A method according to claim 1 wherein the cleaning step includes backwashing the membranes.

3. A method according to claim 1 or 2 wherein the cleaning step includes scouring the membrane surfaces with gas bubbles.

4. A method according to claim 1 wherein the volume of liquid suspension within the vessel is reduced by continuing withdrawal of the permeate from the membranes while the flow of liquid suspension to the vessel is suspended.

5. A method according to claim 4 wherein the continuing withdrawal of permeate step includes applying gas pressure to the liquid suspension to assist the provision of said pressure differential across the membrane walls.

6. A method according to claim 5 wherein the gas pressure is applied by feeding aerating or scouring gas bubbles into the liquid suspension

7. A method according to claim 5 wherein the step of applying gas pressure includes applying a separate source of gas pressure to the liquid suspension.

8. A method according to claim 1 wherein the volume of liquid suspension in the vessel is reduced by reversing the liquid suspension flow into the vessel.

9. A method according to claim 1 wherein the volume of liquid within the vessel is reduced to a predetermined level.

10. A method according to claim 9 wherein the predetermined level is sufficient such that the membranes remain immersed in the liquid suspension during scouring and liquid backwash.

11. A filtration system for removing solids from a liquid feed suspension comprising:

(i) a vessel for containing said liquid feed suspension;

(ii) means for providing a flow of liquid feed suspension to the vessel;

(iii) a plurality of permeable, hollow membranes within the vessel;

(iv) means for providing a pressure differential across walls of said membranes such that some of the liquid suspension passes through the walls of the membranes to be drawn off as permeate

while at least some of the solids are retained on or in the hollow membranes or otherwise as suspended solids within the liquid surrounding the membranes,

(v) means for withdrawing permeate from the membranes;

(vi) means for reducing the volume of liquid suspension in the vessel;

(vii) means for suspending the withdrawal of permeate from the membranes;

(viii) means for cleaning the membranes by dislodging at least some of the retained solids from the membranes;

(ix) means for removing the liquid containing the solids from the vessel.

12. A filtration system according to claim 11 wherein the cleaning means includes means for backwashing the membranes.

13. A filtration system according to claim 11 wherein the cleaning means includes means for scouring the membrane surfaces with gas bubbles.

14. A filtration system according to claim 11 wherein the volume of liquid suspension within the vessel is reduced by continuing withdrawal of the permeate from the membranes while the flow of liquid suspension to the vessel is suspended.

15. A filtration system according to claim 11 wherein the volume of liquid suspension in the vessel is reduced by reversing the liquid suspension flow into the vessel.

16. A filtration system according to claim 11 wherein the volume of liquid within the vessel is reduced to a predetermined level.

17. A filtration system according to claim 11 wherein the predetermined level is sufficient such that the membranes remain immersed in the liquid suspension during scouring and liquid backwash.

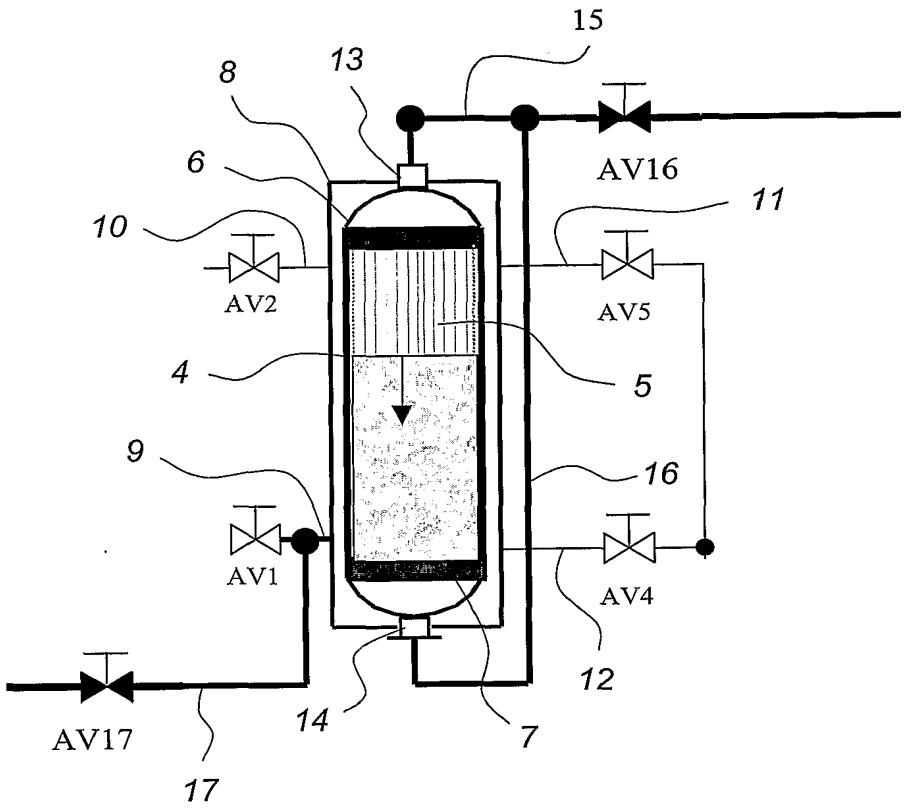

15
8
13
6
AV16
10
11
AV2
AV5
4
5
9
16
AV1
AV4
12
14
7
AV17
17

FIG. 1

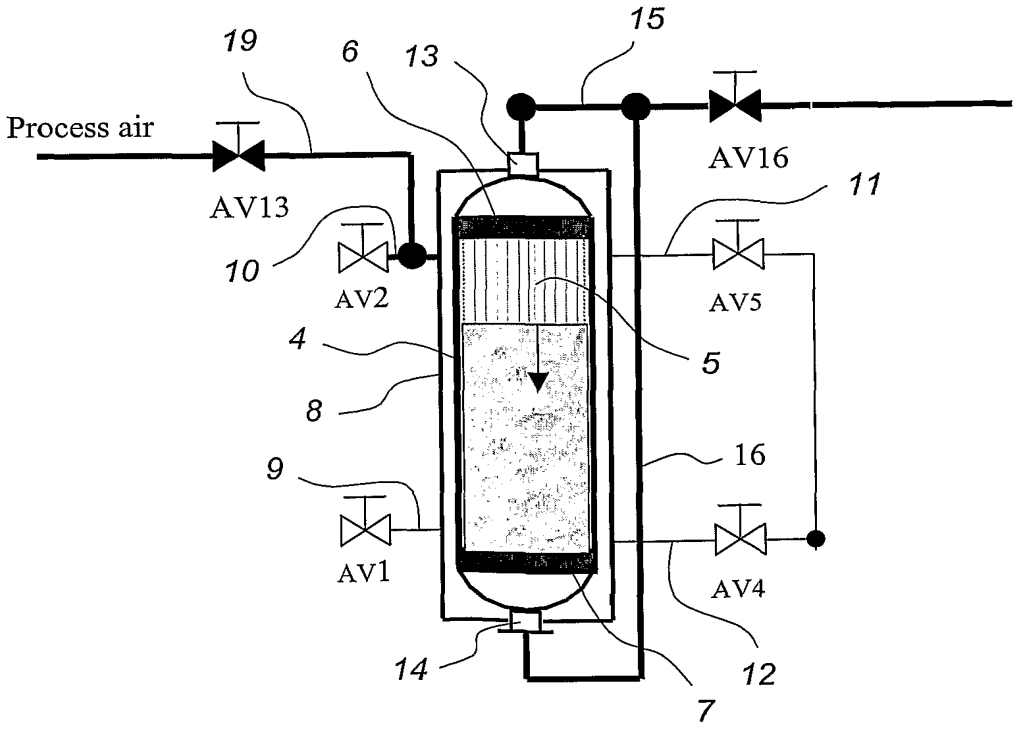

19
15
6
13
Process air
AV16
AV13
11
10
AV2
AV5
4
5
8
16
9
AV1
AV4
14
12
7

FIG. 2

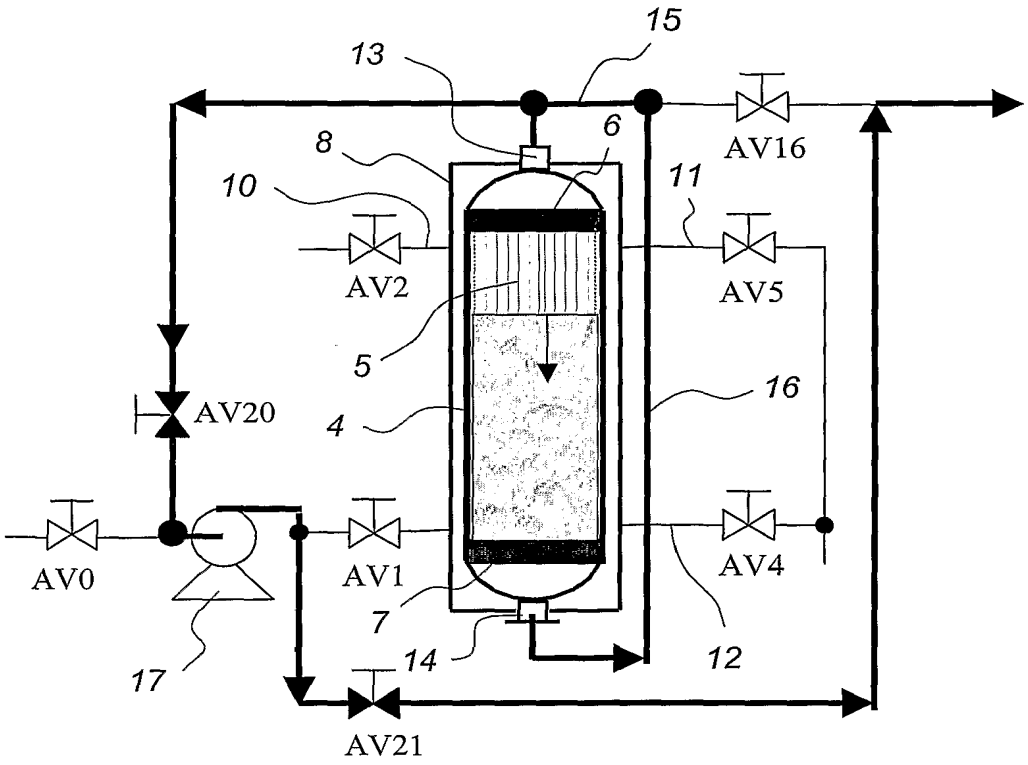

15
13
6
8
AV16
10
11
AV2
AV5
5
16
AV20
4
AV0
AV1
AV4
7
14
12
17
AV21

FIG. 3

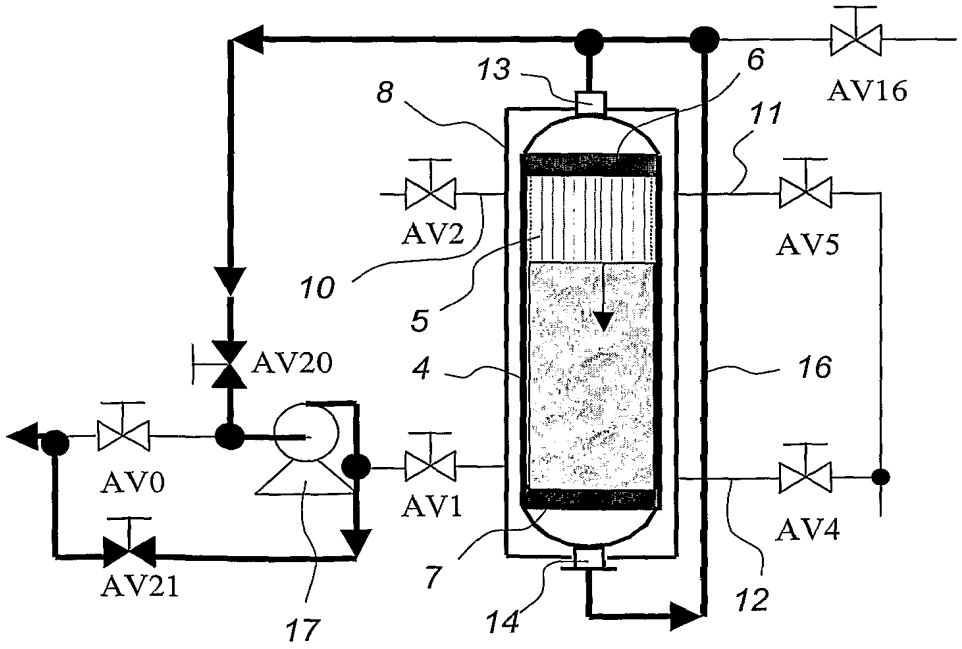

13
6
AV16
8
11
AV2
AV5
10
5
AV20
4
16
AV0
AV1
AV4
AV21
7
14
12
17

FIG. 4

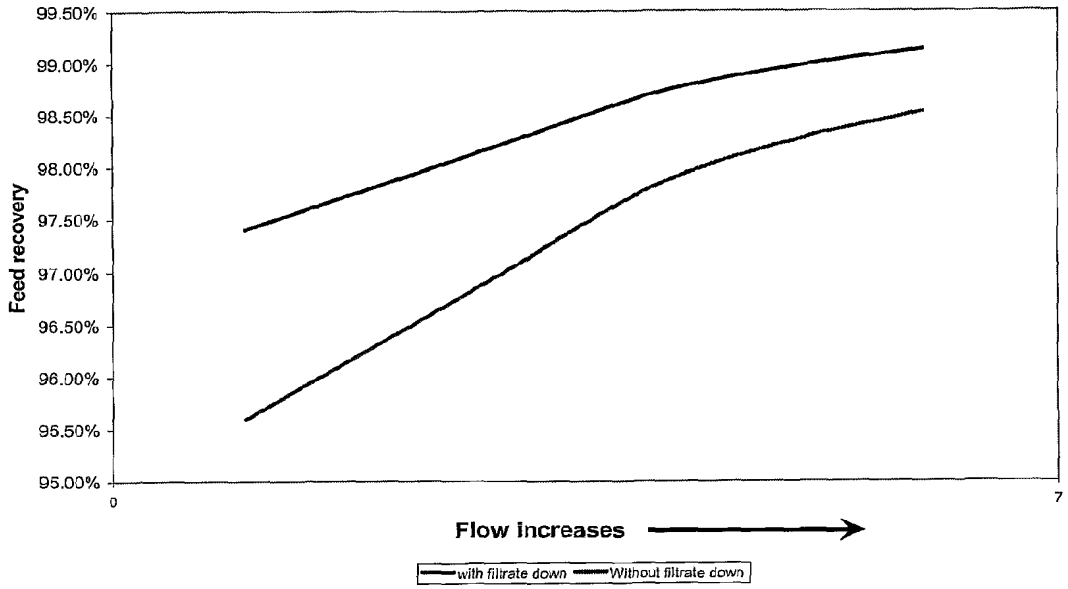

99.50%
99.00%
98.50%
98.00%
97.50%
97.00%
96.50%
96.00%
95.50%
95.00%
Feed recovery
0
7
Flow increases
with filtrate down
Without filtrate down

FIG. 5

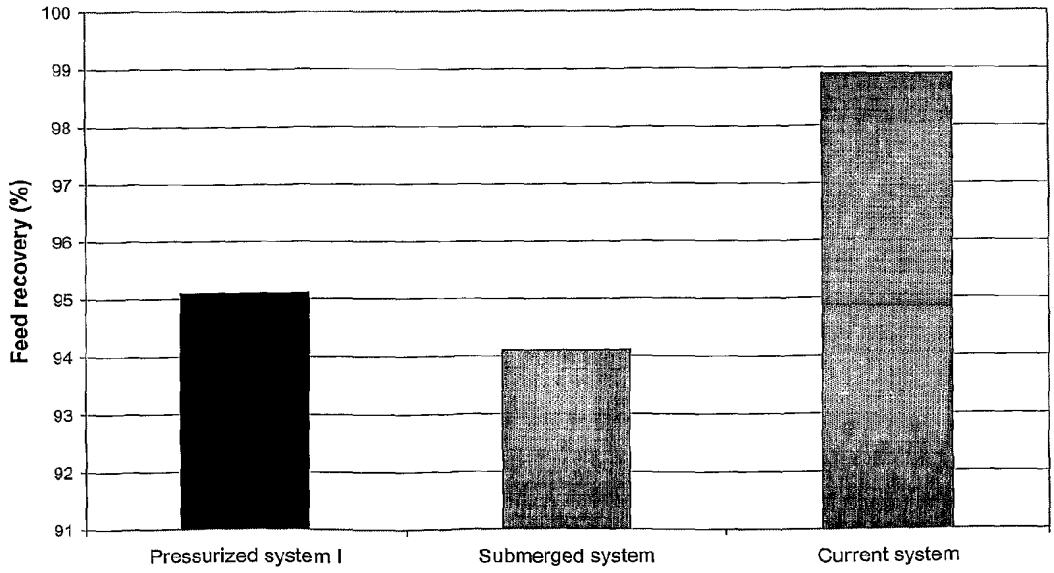

100
99
98
97
96
95
94
93
92
91
Feed recovery (%)
Pressurized system I
Submerged system
Current system

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2005/001356

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: B01D 65/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Derwent DWPI: IPC B01D 61/-, 63/-, 65/- and keywords BACKWASH BACKFLUSH FLUSH CLEAN REDUC MINIM WAST LOSS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2001/008790 A1 (ZENON ENVIRONMENTAL INC.) 8 February 2001 See page 6 lines 21,22; page 7 lines 2-4	1-4,8,9, 11-16
X	WO 2002/030550 A1 (U.S. FILTER WASTEWATER GROUP, INC.) 18 April 2002 See whole document	11-17
P,X	WO 2005/028085 A1 (U.S. FILTER WASTEWATER GROUP, INC.) 31 March 2005 See page 6 lines 12,13; claim 6	1-17

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

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Date of the actual completion of the international search	Date of mailing of the international search report
16 November 2005	21 NOV 2005
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **MATTHEW FRANCIS** Telephone No : (02) 6283 2424

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2005/001356

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Patent Document Cited in Search Report		Patent Family Member					
WO	0108790	AU	62570/00	AU	64190/00	CA	2279087
		US	6303035	US	6547968	US	2001052494
		US	2003146153	US	2004007525	US	2005178729
		WO	0108789				
WO	0230550	AU	91514/01	CA	2424590	CN	1468140
		EP	1328335	NZ	525149	US	6872305
		US	2003234221				
WO	2005028085	WO	2005021140				

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX